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To Mr. G.E. Brown
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INFLUENCE OF 500 kV LINES ON CBL-CJBC COVERAGE FINAL REPORT

R.C. Madge

Field strength measurements of the patterns of the CBL/CJBC radio broadcast antenna at Hornby at 80 test points roughly one year after completion of the second Milton TS-Clairville TS 500 kV line have been made. Comparisons with earlier tests attempt to measure the effects of the line on the patterns. It is shown that any such effects are of the same order as those caused by construction of new structures near the test points, by locally changing ground conductivity, by overall ground conductivity changes, and by operator error. Due to the nature and magnitude of these factors it is impossible to determine the contribution from the transmission line; however, it is expected to be minimal and acceptable. It is sometimes possible to induce large changes in specific small portions of the pattern by isolating sky wires on the towers. These changes are generally offset by opposite changes over the rest of the pattern.

Three 500 kV transmission lines pass by the CBL/CJBC two-frequency radio broadcast antenna at Hornby. The most recent line, the second Milton TS-Claireville TS 500 kV line, has been complete for more than a year. In order to try to determine the effect these lines have on the radio station, field strength tests have been taken on a 16 km circle around the transmitter site over the last seven years. Test Nos 9 and 10 were taken in late October/early November, 1983 approximately one year after Test No 8 which was taken following completion of the third line. Test No 9 was taken with the skywires of Towers 14 to Towers 24 of the third line insulated from the towers. This

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represents the exact configuration present during Test No 8.[1] Immediately following Test No 9 the skywires were connected to all of the towers. Then, with three test points being monitored, skywires were insulated from certain towers one-by-one (Test No 9A). The results were analyzed and an optimal configuration was arrived at. This configuration was used for Test No 10 which was started the next day.

Field Measurements

Tony Caruso of the CBC, Tony Van Schyndel of the Department of Communications, and Rick Madge of Ontario Hydro, took part in these measurements. Field strength readings were taken around the 80 test points in both Test Nos 9 and 10 for each of the CBC frequencies, 740 kHz and 860 kHz. Table 1 on page 3 summarizes the dates and line configurations for Test Nos 1 to 10. For reasons explained in the first three progress reports/1,2,3/, and amplified later in this report, the first four sets of measurements are deemed to be invalid for close analysis.

Analysis of Data

Test Nos 9 and 10 results will be compared with each other, with Test No 6 and with Test No 8. The analyses are carried out as follows:

1. Using the CBC antenna current and antenna impedance, each reading is adjusted for exactly 50 kW output. This cancels out any CBC antenna variations from one test to the next.

2. During the testing, test points were labelled as "BAD POINTS", "QUESTIONABLE POINTS, or "ACCEPTABLE POINTS". The reasons a test point would be labelled BAD or QUESTIONABLE were varied. It was agreed by the group that the BAD POINTS would be excluded from all analyses and the QUESTIONABLE POINTS would be included but flagged in all analyses.

3. At each test point the average of the meters is calculated.

4. The average of all test points is calculated. To cancel changes in ground conductivity over the whole area, this average is scaled to a common number (equal to the Test No 1 average). Each test point average is then multiplied by this scaling factor. Some discussion of overall ground conductivity scaling factors will follow.

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[1] Unfortunately, due to lack of proper communication with the Construction Division, the previous Report/3/ erroneously stated that the Test No 8 configuration was that of the skywires connected to all towers.

Table 1

Test No	Transmission Line Condition	Date
1	No power lines	October 1976
2	Towers only - first two lines	June 1977
3	Both lines complete	October 1977
4	Skywires isolated on selected towers of both lines	November 1977
5	Identical to No 4-Coverage tests at different locations using different test points	July 1978
6	Identical to No 4	November 1981
7	Towers only - 2nd Milton TS - Claireville TS 500 kV line	April 1982
8	2nd Milton TS - Claireville TS 500 kV line complete,skywires isolated on Towers 14 - 24	October 1982
9	Identical to No 8	October 1983
9A	Three test points monitored as skywire configuration of test No 8 is changed, tower-by-tower	November 1983
10	Similar to No 8,but skywires isolated on selected towers only	November 1983

5. The scaled test point averages are then compared to other tests.

The analysis of Test No 9A did not include any scaling or averaging. One meter was located at each of test points 46, 47 and 48. The raw data contained in Tables 2a and 2b are to be compared only to one another. The actual values do not correspond to values from any other test.

Discussion of Results

Figures 1 and 2 represent the ratio of Test No 9 values to Test No 8 values for CBL, 740 kHz, and [illegible], 860 kHz respectively. Since the transmission line configurations were identical in both tests, these graphs represent changes in field strength

over one year due to all other causes. Possible factors would be construction of new structures near test points, locally changing ground conductivity and operator error. We can see the changes are all on the order of less than 10%. The fact that these differences are relatively small can be attributed to a number of things. First, both sets of readings were taken in October in similar weather conditions. Second, new construction during 1983 was at a much lower rate due to the weakened economy. Third, great care was exercised while taking readings to minimize operator error. Contrast these graphs with those representing Test No 6 to Test No 4 from the first Progress Report/1/. Under identical transmission line configuration and with a passage of four years, the differences reached a maximum of 24% for both frequencies, with many points well over 10%. As both tests were taken in November (1977 and 1981) the greater differences can be attributed to greater operator error in Test No 4 (as discussed later) and to a much higher rate of new construction. In any case, Figures 1 and 2 show a year-to-year variation of under 10%.

Table 2a

Test No 9A	CBL - 740 kHz Readings in mV/m		
Configuration	Test Point 46 (DOC)	Test Point 47 (CBC)	Test Point 48 (OH)
All isolated (Test #9)	68	70	74
All connected	90	98	91
Tower #24 isolated	87	96	91
Then #14	88	95	93
Then #23	90	105	95
Then #15	91	109	94
Then #22	91	109	94
Then #16	89	90	91
Then #20	90	92	92
Then #18	89	92	91
Then #19	71	75	79

Test Point 46 = 125° azimuth
Test Point 47 = 120° azimuth
Test Point 48 = 116° azimuth

Table 2b

Test No 9A	CBL - 740 kHz Readings in mV/m		
Configuration	Test Point 46 (DOC)	Test Point 47 (CBC)	Test Point 48 (OH)
All isolated (Test #9)	117	152	118
All connected	125	154	120
Tower #24 isolated	123	158	119
Then #14	119	158	119
Then #23	120	155	120
Then #15	123	158	120
Then #22	122	160	119
Then #16	119	157	120
Then #20	126	157	121
Then #18	116	160	121
Then #19	118	163	122

Graphs comparing Test No 9 to Test No 6 were dispensed with, in favour of Test No 10 to Test No 6 ratios, as discussed later.

Following Test No 9 all the skywires were connected to the towers in preparation for Test No 9A. Tables 2a and 2b contain the raw data of Test No 9A taken at three test points while skywires were individually isolated from selected towers. With the field strength meters on tripods, readings were taken after each additional skywire was isolated from the tower. The purpose of this test was two-fold, to observe the effects of isolating skywires under controlled conditions, and to choose an optimal configuration for the transmission line to be left in. It can be seen that dramatic changes occurred with different configurations and at different test points for CBL-740 kHz, while no such changes were noticed for CJBC-860 kHz. The greatest effect occurred at CBL-740 kHz when the last tower, Tower No 19, (which was also the closest to the transmitter) was isolated. In this case only, did all three test points display any remarkable changes. Note that these changes brought the values down to those of Test No 9 where skywires on Towers 14 to 24 were all isolated. The sequential nature of connecting the towers probably had something to do with it; however, this tower has been noted in past field tests and computer runs to be a strong 740 kHz reradiator when isolated. Obviously, Tower No 19 in this line has some interesting resonant qualities at 740 kHz.

A choice of optimal configuration was somewhat hard to make. Since all changes other than the one noted above affected one test point only, there was no clear cut choice. It was decided that the configuration would have to have consistently high relative values. The one chosen was with Tower Nos 14 to 16, No 20, Nos 22 to 24 isolated. This choice is underlined in Tables 2a and 2b.

One week after Test No 9 and the day after Test No 9A, Test No 10 was started with the optimal configuration chosen from above. Figures 3 and 4 represent the ratios of Test No 10 values to Test No 6 values for the two radio stations frequencies. These ratios represent the effect of the third line, changes due to two years passage of time and operator error. All differences are less than 20%, and only 4 readings in CBL and 7 readings in CJBC are over 12%. Considering operator error and the effects seen in Figures 1 and 2 of one year's passage of time, the effects of the third line can be said to be minimal and acceptable.

Figures 5 and 6 represent the ratio of Test No 10 values to Test No 9 values. These curves represent the effect of reconfiguring the third line, changes due to one weeks passage of time and operator error. Since there were no drastic weather changes the effects over one week can be ignored. This leaves the effect of connecting certain skywires and operator error. In Figure 5 we see a marked increase at azimuths 116°, 120° and 125° corresponding to test points 48, 47 and 46 respectively. Test point 43 at 140° is also higher. (Test points 44 and 45 were declared BAD POINTS.) Our optimal configuration chosen in Test No 9A predicted these markedly higher field strengths at these azimuths when compared to Test No 9. It is interesting to note in Figure 5 that the next biggest variation occurs as a decrease at an azimuth of 307°, roughly 180° away from our dramatic increases. The predicted increases represent the only major change in signal strength, and are offset by a generally small decrease in signal strength over the rest of the pattern.

Before we make any generalized statements to this effect, we should remember that the two sets of readings were both normalized to a common number - the Test No 1 overall average. Therefore in effect we have positioned the graph vertically to arrive at an average ratio of 1.00. A look at Table 3 however shows that the Test No 10 overall average was only 2.7% higher than the Test No 9 average for CBL. Factoring this out would raise the curve roughly 2.7%, which is not enough to invalidate this generalization.

There was little change experienced at CJBC-860 kHz due to the reconfiguring of the line. Figure 6 shows 4 test points with variations over 10% all grouped around azimuth 270°. All other variations were under 10%. Test No 10 was only 1.2% higher than Test No 9, so we can say that the increases roughly offset the decreases.

The effect of isolating and connecting skywires seems to be to redistribute the signal around the horizontal pattern. A configuration may be found to induce a maximum over a given azimuthal range, yet this will be countered by a general decrease everywhere else.

Table 3 lists the overall test averages for each frequency after being corrected to 50 kW. Step 4 in the Analysis of Data Section above corrects these values to the Test No 1 value, yet it is worthwhile to look at these unscaled values. These represent real changes in signal that are factored out for analysis. Observe a 19% maximum variation in CBL and 20% maximum variation in CJBC. These are further variations in signal strength experienced by listeners, above and beyond the effects of transmission lines and other reradiators.

Test Nos 8 and 9 represent identical transmission line configurations one year apart and yet we see 6% and 5% variations in overall received signal. These variations, subsequently hidden by our analysis, reflect the generally volatile nature of received signal field strength.

Table 3

Overall Test Average Signal Level
(Corrected to 50 kW)

Test No	Date of Test	CBL	CJBC
1	October 1976	112.8 mV/m	115.7 mV/m
2	June 1977	110.2 mV/m	107.4 mV/m
3	October 1977	115.1 mV/m	110.9 mV/m
4	November 1977	109.1 mV/m	112.3 mV/m
6	November 1981	98.6 mV/m	101.7 mV/m
7	April 1982	93.1 mV/m	95.9 mV/m
8	October 1982	103.1 mV/m	95.1 mV/m
9	October 1983	97.3 mV/m	100.4 mV/m
10	November 1983	100.0 mV/m	101.6 mV/m

Discussion of Operator Error

We feel it is important in each test to identify the calculated operator errors in order to have confidence in the data from that test. The rather lengthy method of calculation is listed in Appendix A of Progress Report No 3/3/.

Table 4 summarizes the operator errors of all the tests to date. The column for each frequency marked "SPREAD" represents the limit of operator error from maximum negative variation to maximum positive variation. "BAD POINTS" were not included in this analysis.

The operator errors of Test Nos 9 and 10 are all relatively low. In fact, the operator error of Test Nos 6 to 10 are all much smaller than those of Test Nos 1 to 4 both in terms of the "SPREAD" and the Standard Deviation of error. The errors of Test Nos 1 to 4 (and especially Test Nos 2 and 3) are so high we feel that these tests should be discounted completely. If included they would add further uncertainties in any analysis of anywhere from 6 to 18%. Since it has been demonstrated from Test Nos 6 to 10 that low operator error tests can be performed, the operator errors of Test Nos 1 to 4 are unacceptably high.

Concern has been voiced over the stress we give to the "SPREAD" when dealing with operator error. These spreads represent the errors from only two test points. It should be pointed out that since we are trying to cover 360° of azimuth with 80 test points, each test point must cover 4 to 5° of azimuth. We must calculate operator error on the basis of each test point because each is so important. A look at any of our graphs will demonstrate the effect one test point can have if it deviates from surrounding test points by 10% or more.

Progress Report No 3/3/ goes into a much more detailed explanation of the effects of high operator error.

Conclusion

Test Nos 9 and 10 represent high confidence level sets of readings taken roughly one year after completion of the third line passing the CBC antenna - the second MILTON TS - CLAIREVILLE TS 500 kV line. Towers 14 to 24 of this line were isolated in both Test No 9 and Test No 8 taken one year previously. Comparison of Test No 9 and Test No 8 show that year-to-year variations (plus the effects of operator error) are less than 10%. Test No 9A involved monitoring three test points while skywires were isolated on selected towers. Dramatic

Table 4

Test #	Meter	CBL - 740 kHz				CJBC - 860 kHz			
		Standard Deviation %	Variation			Standard Deviation %	Variation		
			Max+ %	Max- %	Spread %		Max+ %	Max- %	Spread %
1	CBC 1	3.4	8.0	-8.8	16.8	3.3	7.7	-10.4	18.1
	CBC 2	3.0	6.7	-5.3	12.0	3.2	10.1	-6.0	16.1
	CBC 3	2.9	6.2	-12.7	18.9	2.1	3.3	-7.9	11.2
2	CBC 1	6.2	45.1	-12.9	58.0	6.5	44.5	-21.1	65.6
	CBC 3	5.3	11.1	-38.8	49.9	5.6	18.2	-38.5	56.7
3	CBC 1	5.3	12.1	-13.1	25.2	5.1	14.4	-15.7	30.1
	CBC 2	3.9	13.2	-11.7	24.9	4.0	10.4	-7.2	17.6
	CBC 3	4.0	9.3	-10.2	19.5	3.5	8.2	-7.7	15.9
4	CBC 1	3.8	12.8	-10.9	23.7	3.5	11.5	-10.1	21.6
	CBC 2	2.7	6.3	-6.0	12.3	2.4	8.0	-6.1	14.1
	CBC 3	3.2	10.4	-9.1	19.5	2.8	7.2	-6.6	13.8
6	OH	1.3	4.2	-3.7	7.9	1.1	3.5	-2.2	5.7
	Cons	1.3	3.7	-4.2	7.9	1.1	2.2	-3.5	5.7
7	OH	1.3	2.4	-3.2	5.6	1.3	2.9	-3.2	6.1
	Cons	1.4	3.0	-3.5	6.5	1.3	2.8	-3.2	6.0
	CBC	1.7	4.7	-3.4	8.1	2.4	6.4	-3.4	9.8
	DOC	1.9	3.9	-4.4	8.3	2.3	5.6	-6.7	12.3
8	OH	1.1	4.5	-2.2	6.7	1.2	5.9	-3.0	8.9
	Cons	1.7	3.8	-5.3	9.1	1.5	4.4	-3.4	7.8
	CBC	1.5	4.0	-4.0	8.0	1.5	5.3	-4.6	9.9
	DOC	1.3	2.8	-3.9	6.7	1.6	3.4	-5.2	8.6
9	OH	1.3	2.8	-3.3	6.1	1.4	2.9	-5.6	8.5
	DOC	1.5	3.6	-4.1	7.7	1.7	3.4	-5.0	8.4
	CBC	1.8	5.5	-3.5	9.0	1.6	6.7	-2.6	9.3
10	OH	1.1	2.5	-2.6	5.1	1.2	2.6	-2.9	5.5
	DOC	1.7	4.2	-4.0	8.2	1.8	4.3	-5.0	9.3
	CBC	1.3	4.1	-3.6	7.7	1.4	5.7	-2.4	8.1

changes were noticed at certain test points for certain configurations for CBL-740 kHz. No such changes were noticed for CJBC-860 kHz.

An optimal configuration was chosen and left up for Test No 10. Comparisons of Test No 10 with Test No 6 taken before the start of construction of the third line show variations on the order of 10% with a few readings reaching as high as 20%. These variations can be attributed to the presence of the third line, locally changed ground conductivities, new construction in the two years between the tests and operator error. Taking all factors into consideration, it is considered that the contribution to the variations by the transmission line is minimal and acceptable. As well, the overall ground conductivity, although factored out of the analysis, represents a variation on the same order or larger than the expected contribution from the transmission line.

Comparisons of Test No 10 and Test No 9 taken one week apart show that major changes may be induced in a pattern by isolating skywires but that these changes are very azimuthally specific and are generally offset by the rest of the pattern.

Comparisons of Test Nos 9 and 10 with any of Test Nos 1 to 4 were not performed due to the unacceptably high level of operator error experienced in those early tests.

At the conclusion of these tests, skywires were left isolated from the towers on tower nos 14 to 16, no 20 and nos 22 to 24.

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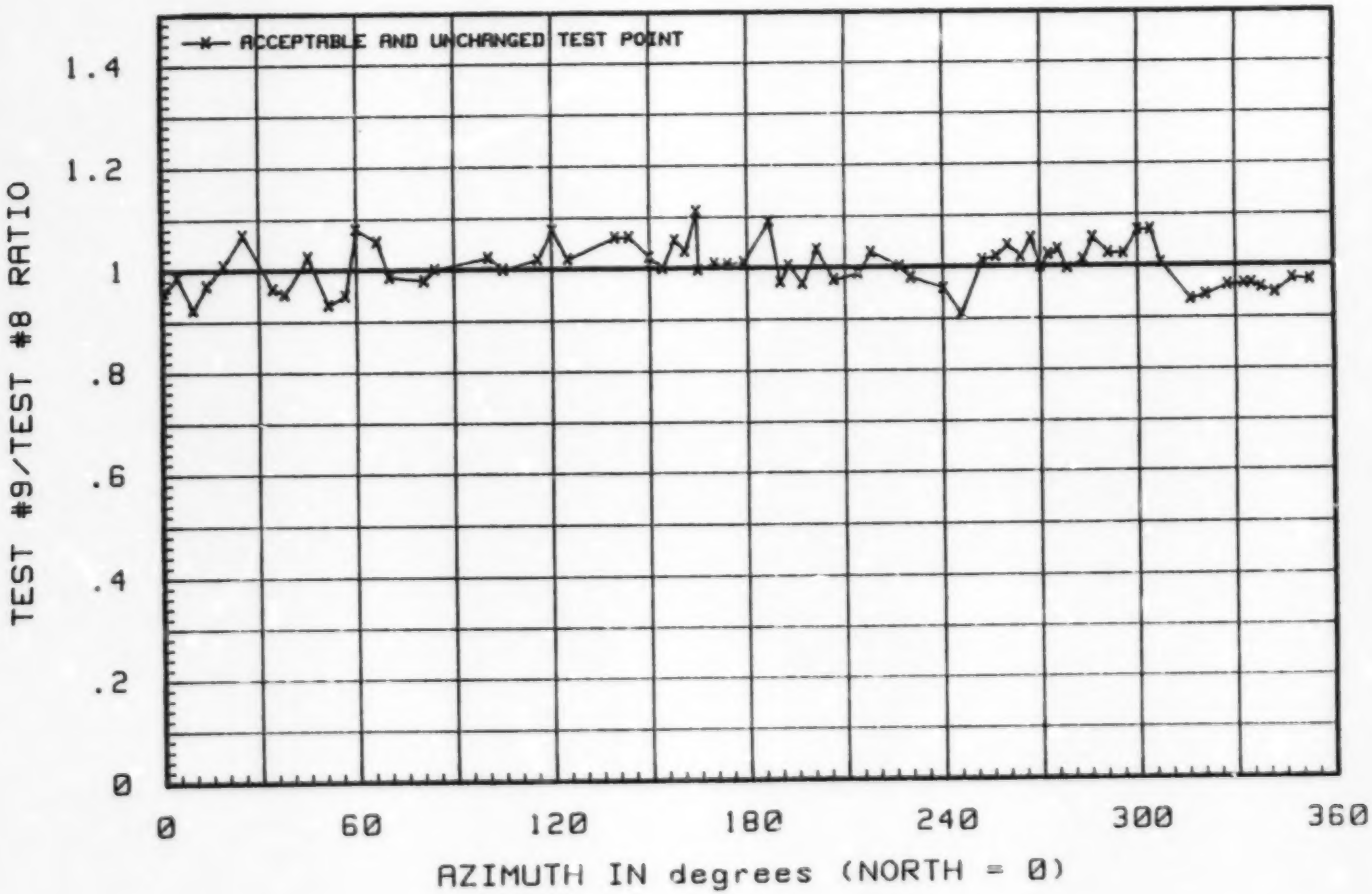
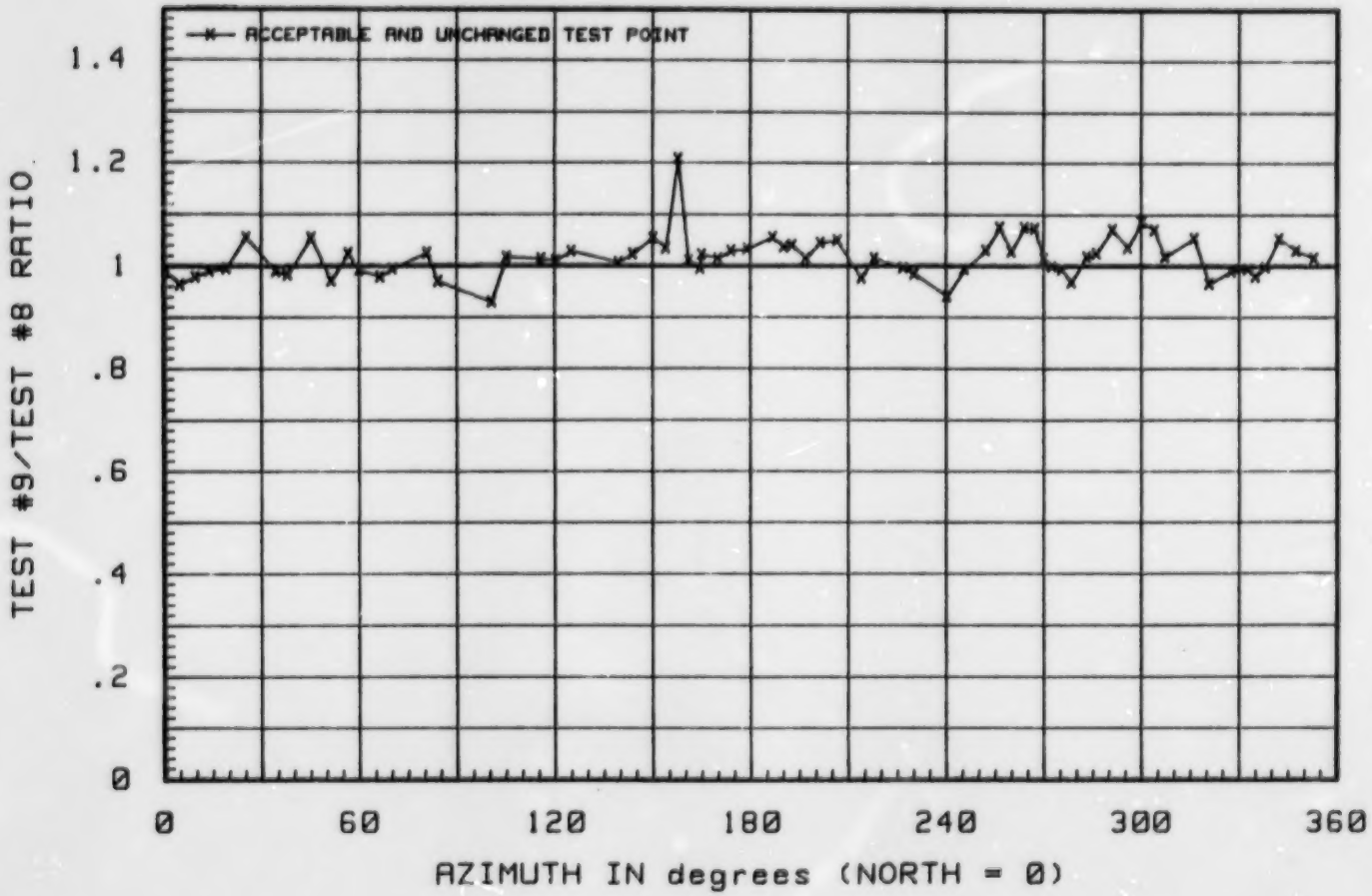
NOTE: References 4 to 8 were prepared by the CBC on behalf of the three co-operating groups: CBC, Ontario Hydro, Department of Communications.



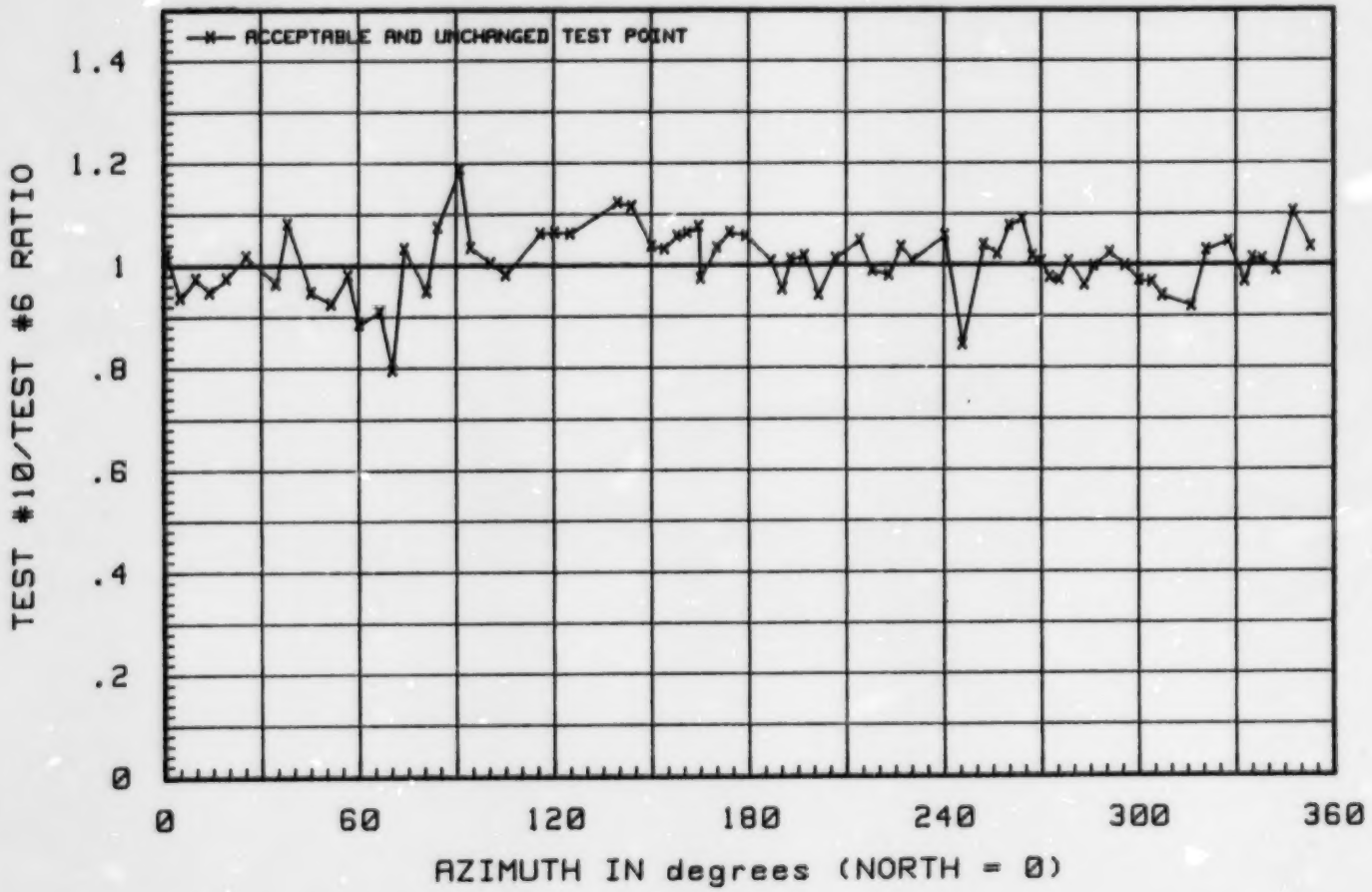
CBL FIELD STRENGTH MEASUREMENTS
RATIO OF TEST #9/TEST #8

FIGURE 1.



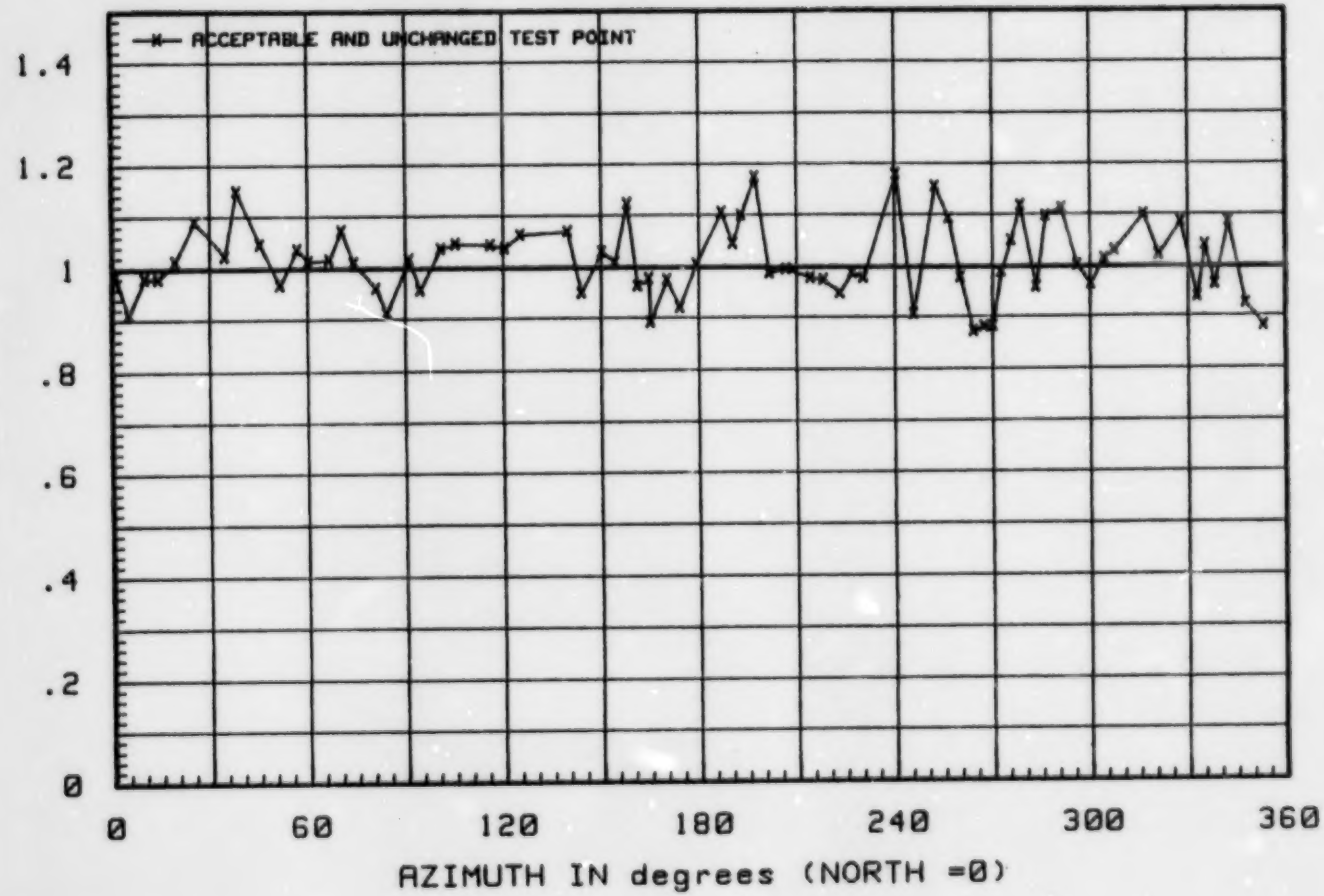
CJBC FIELD STRENGTH MEASUREMENTS
RATIO OF TEST #9 TO TEST #8

FIGURE 2.



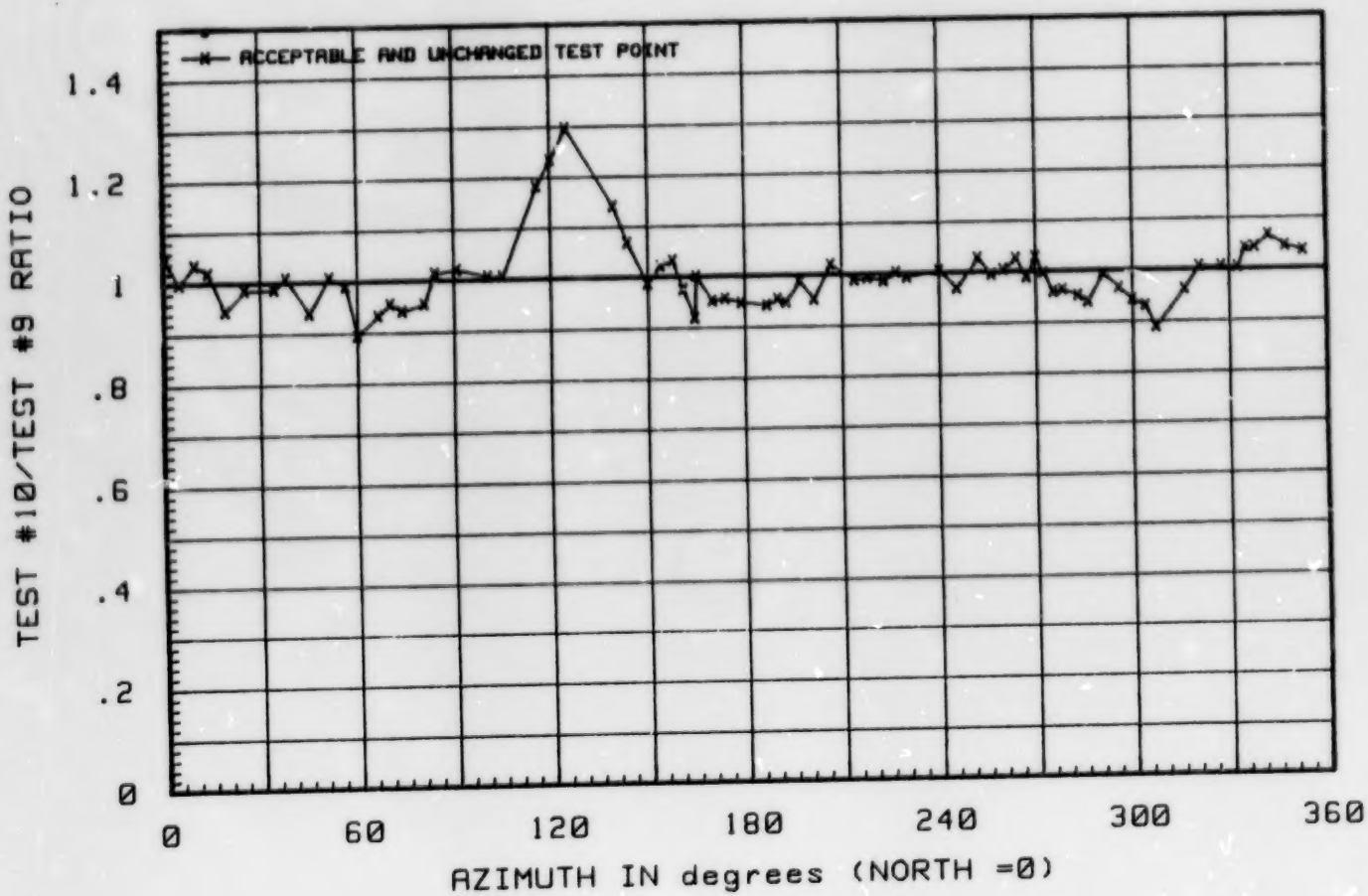
CBL FIELD STRENGTH MEASUREMENTS
RATIO OF TEST #10 TO TEST #6

FIGURE 3.



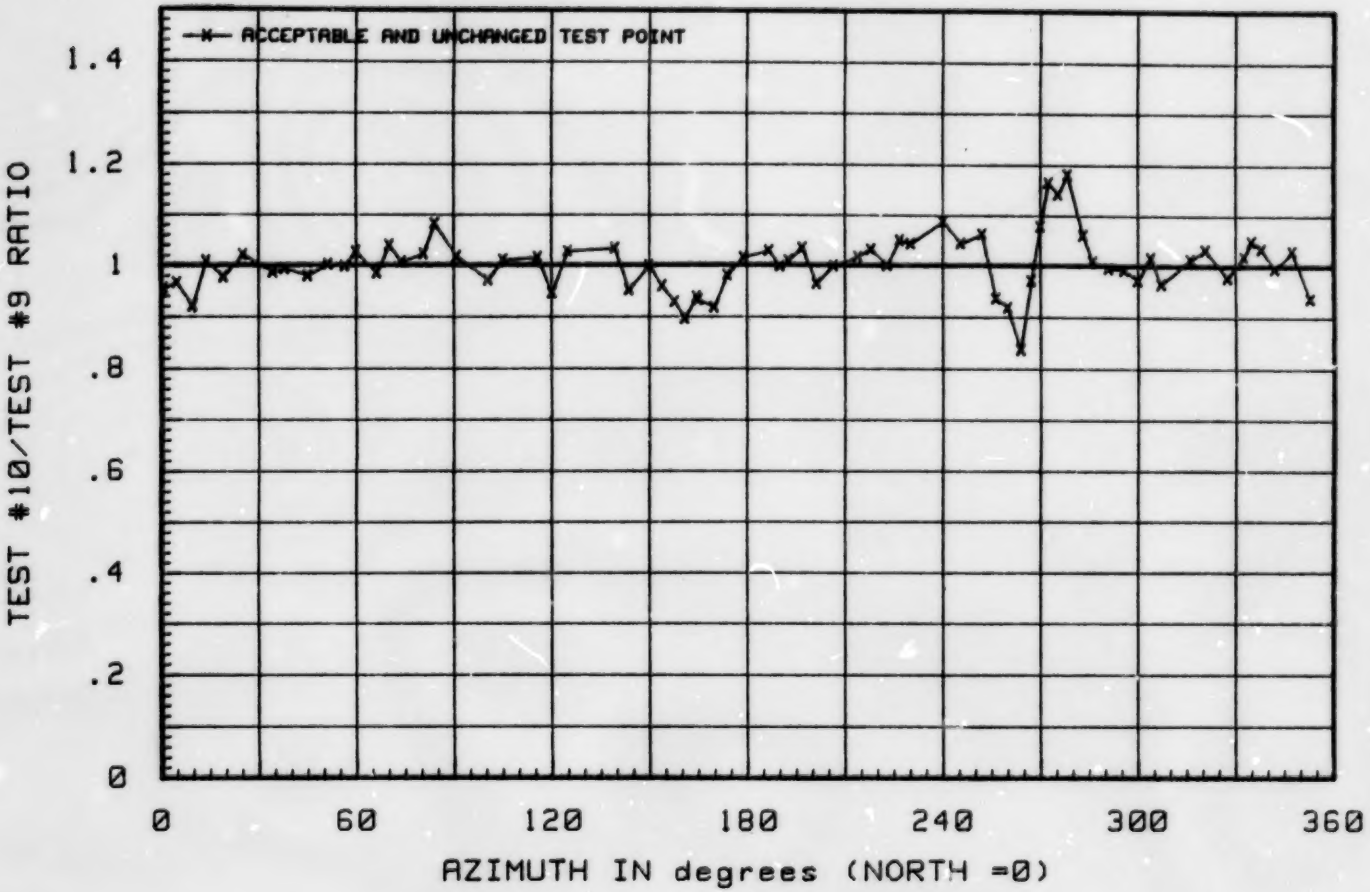
CJBC FIELD STRENGTH MEASUREMENTS
RATIO OF TEST #10 TO TEST #6

FIGURE 4.



CBL FIELD STRENGTH MEASUREMENTS
RATIO OF TEST #10 TO TEST #9

FIGURE 5.



CJBC FIELD STRENGTH MEASUREMENTS
RATIO OF TEST #10 TO TEST #9

FIGURE 6.